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An observational preliminary study on morphological features and methods of use of garad pods (Acacia Nilotica Fruits) from Sudan

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Abstract
Garad is the fruit of the Acacia nolitica plant, which is in the form of pods containing the seeds**.** This study aimed to record and report some of the features of the Garad pods taken from the Savannas area and the Nile River region from central Sudan, and study some methods of using these pods. This is an observational, and preliminary study partially conducted in a simple laboratory, used simple techniques, and supported by photographs taken in real-time from the research samples**.** Results showed that. Some differences between morphological features of the two types of Garad pods were noted, the most prominent of which was the semi-curved string shape for Type 2 pods, compared to the deeply segmented pod chains of Type 1, this segmentation causing the abundance of single or dual pods (broken chain)**.** The smaller Garad pods (type 1) elaborate more smoke on burning (incense) than larger pods (type 2)**.** The peel (shell) of the pod is the most smoke emitter, and the inner layer between the peel and the seed which contains tannin is responsible for the pungent taste of Garad. We concluded that types of Garad pods can be distinguished by their morphological features, particularly the segmentation between seeds. This type of primary observational study, hopefully, encourages researchers in poor areas that lack expensive and modern sophisticated laboratory technologies.

Keywords: garad pods, Acacia nilotica, observational, morphological features, usage

Introduction

Acacia & Garad pods

The genus of trees Acacia is a member of the Fabaceae family. The trees are pod-bearing, with leaves contain tannins used as preservatives, pharmaceuticals, and in tanning leather industries. The origin of the term Acacia may refer to the Greek (*akis*, thorn), and the term nilotica may be related to the Nile river [1].

There are around 1300 Acacia species found worldwide. Acacia Senegal produces a famous type of Gum, called True gum Arabic, which is abundant in some tropical West African regions extending as a belt extending from Senegal to northern Nigeria including Sudan [2].

The Acacia tree was called 'the tree of life' in some ancient Egyptian cultures. In Exodus, as written in Easton's Bible Dictionary, God instructed Moses for building the Tabernacle of Acacia tree wood. The burning of Acacia wood as a form of incense is mentioned in the Bible. It was thought that Acacia smoke put the Gods in a better mood, and keep ghosts away [1].

Garad pods are also called 'Pods of Babul' (Acacia spp.) [3]. The Acacia species (wattles) encloses its seeds in small twisted pods very rich in protein [1]. The inner bark of Acacia nilotica contains 18-23% tannin, Acacia nilotica pods also contain tannin, tanners use both plant parts. The dark brown, finely hairy pods (fruits), is the world's premier source of tannins and it is widely cultivated in warm temperate to tropical areas for its wood and tannins [4].

The color of pods slightly varies between light green or deep red, but both types taste the same, and their ground seeds are had a slightly garlicky flavor. Acacia had a self-protection system against pests and grazing animals, composed of organic compounds, still, small beetle fly in, pierce the pods, and lay their eggs within [1].

Uses

Acacia nilotica fruits, Garad pods, known in Sudanese folk medicine as 'kaarad' [5], were used by people in rural areas as a remedy for many alignments not restricted to the respiratory system [6], but include skin diseases, and diseases caused by many microorganisms. Antifungal activity of Garad pods was also reported by different researchers [7]. The study of Abdallah (2016) [8] showed that the Garad pods are a potent antioxidant. These pods also contain some psychoactive alkaloids [1].

Besides medical use, Garad is used extensively in Sudan by rural tanners, as the tannin content of Garad pods is approximately 30% of the total weight [9, 10, 11]. Animals as sheep and goats eat Garad pods and disseminate seeds [12].

When soaked in water, Garad pods filtrate may cure some bowel syndromes, when sucked Garad pods help in curing some throat problems, while burning the pods as incense can refresh the air by disinfecting the atmosphere [3]. The fresh Acacia nilotica pods were used in the cure of some sexual and urine-genital disorders including pelvic prolapsed [13-16].

The Garad exhibited an antibacterial activity at high concentrations and bacteriostatic at lower concentrations. Abdallah (2016) [8] suggested that The anti-microorganism activities of Garad may be considered as a scientific basis

for the traditional use of Garad by Sudanese against many alignments.

Sudanese use almost all parts of the Acacia tree, fruits, flesh, and seeds. The entire fruit, the Garad, is used to cure Malaria by soaking in water, and they inhale the smokes elaborated from Garad burning to cure treating phlegmatic coughing [17].

Smoke

Smokes of some medicinal plants were used for curing diseases, but not deeply studied, and knowledge is not enough about these medicinal properties. Fabaceae comprises (9.8%) of these plants. Some plant smokes is used by rural societies as a repellent or preservative [18]. Some opinions review argues the possibility of using smoke as a promising source of a new delivering method of drugs.

The main method for administering smoke is inhalation, which is 71.5% of the indications for the treatment of pulmonary and neurological disorders. Smoke is either used as a local treatment directed to the infected organ of the body, such as in case of skin disorders, or used for air purifying. Smoke-based remedies had many advantages, they had a lower cost, and they were easily absorbed by the brain and body tissues [18].

Toxicity

Some toxic effects of Garad were detected by Medani *et al*. (2016) [19], they reported a low appetite and intermittent loss of voice in their study on Nubian goats. They related these signs and the mortality rate to the high dose of tannin. Despite such study results, Sudanese feed their animals like sheep, goats, and camels with Garad pods to improve milk production [20].

About this study

It is thought that most of the immense wealth of medicinal plants in Sudan is still unexploited [21]. "Garad" is one of these understudied plants.

Many types of researches in literature had been conducted about the Acaia trees and the usage of their parts including the bark of the tree and the gum produced by some Acaia species [22, 23], in addition to seeds, and leaves [24], besides studies on young Garad pods, which is chewed as an antiscorbutic [22].

We suggest, according to the vast spread of the usage of pods produced by Acaia nolitica, that, these pods which contain seeds are a fertile field for investigating and researching. We didn't find enough Pharmacognostical work been carried out on mature dry pods/fruits. Hence, we have carried out these macroscopically, and preliminary morphological studies on the fruits of Acacia nilotica called: the Garad.

Most of the laboratories in the underdeveloped or third world countries lack the sophisticated instrumentation and the skills for operating these research tools and the expert scientists who were capable of interpreting the complicated results and outcomes of such instruments. Sudan is one of those countries. We tried to prove the possibility of conducting scientific research without using complicated and expensive laboratory instruments and gaining beneficial results which may develop our life.

This preliminary study used a simple methodology and based on observing and reporting some morphological features of some Garad types (Acacia fruits) from Western and Central Sudan regions, besides discussing some methods of usage of Grad pods in Sudan.

Methodology

Acacia nilotica fruits (the Garad pods) were purchased from Omdurman (Central Sudan) local markets. Part of this work was carried out in Sudan Customs laboratory, Khartoum, but the major part of the observational study was done at home in an appropriate environment, where observed features had been immediately reported either by writing or photographing. The removal of the crust (peel) from the pod flesh was easily done manually when needed.

The features of each Garad type were observed, detected, and reported in real-time by noting and photographing, then supported by the literature reviewed, then some comparisons declared in a table. In this study, the term "pod" means a single pod – NOT a chain of pods, so that the chain of Garad contains many single pods. One pod contains one seed.

Some data concerning the use of Garad in Sudan (statistical details not shown) were collected from a group of 200 people using a random survey and personal communications (females, males, and herbalist males).

Our selection has been based on the desire to evolve the simplest possible procedure, using the least expensive techniques. The Garad pods were taken in to by hand for counting 100 pods. The weight of the Garad pods was measured in a weighing balance (g/mg). Test weight is used as an indicator of the approximate density of pod bulk (Bern and Brumm 2009) [25]. To that end, in this study, we just aimed to give an approximate view of the density of Garad pods, which was done by calculating the weight of 100 single pods. Notifying that the test weight in the literature is usually used for seeds, but we used the technique for pods that contain seeds and other constituents.

As our study was observational, we didn't use any sophisticated instrumentation for detecting different smoke qualities or quantities. Smoke elaborated was detected by putting an inverse glass cub of a volume about 310 Cm Cubic over the burning pods, then after about 30 seconds of burning, the smoke captured into the cub, then observed and photographed. Nearly, the same conditions were applied to all samples, using naked eye observations. A comparison of smoke densities obtained in simultaneous sampling is given in the Figures shown in the result section of this paper. Garad pods were burned in a local heritage tool called "Mobkhar" (incense burner) (Fig 1).

Fig 1: Photographic Album of "Mobkhar" (incense burner) shape and use

Results and Discussion

Our study was done on dry mature Garad pods, obtained from local markets in Omdurman city - the national Capital of Sudan, Garad pods were identified and confirmed by the collection of knowledge gained from many concerned expert persons who were related to the field, besides that, Garad is a well-known material by everybody in Sudan. The smell of Garad pods incense is carrying memories for most Sudanese people, "I remember the shape and smokes smell of Garad since my childhood".

Morphology - Two types of pods

Garad is a well-known item in most houses in Sudan, it exists in most markets at a cheap price. The pod is the fruit that contains Acacia seeds**.** The Garad pods were dry, and somewhat rigid, exist either as impact segments (chains) or broken into single, dual, or triple pods. On studying the pods of Acacia nilotica, selected for the present study, we observed two types of Garad pods, they were similar in many features and differ in some. Type 1 Garad was in the shape of single, dual, or triple smaller pods broken from a chain of a clear segmentation between pods. This Garad type was said to be brought from sub-Saharan regions and the River Nile areas near the countryside of cities in central Sudan. Type 2 Garad was in the shape of an intact chain contain about 7-8 pods (i.e. 7-8 seeds), somewhat larger and darker, distinguished by a slightly curved shape without clear segmentation between pod units. Segmentation seems to facilitate the breakdown and splitting of pod chains into single pods or pair of pods. The chain length of type 2 pods was about 7 Cm, while the width (diameter of the circular pod) for both types was about 1.5 Cm. Andrews (1952) [26] studies reported a pod length of about 10-15 cm with constrictions between the seeds **(**Figures 2; 3; and 4).

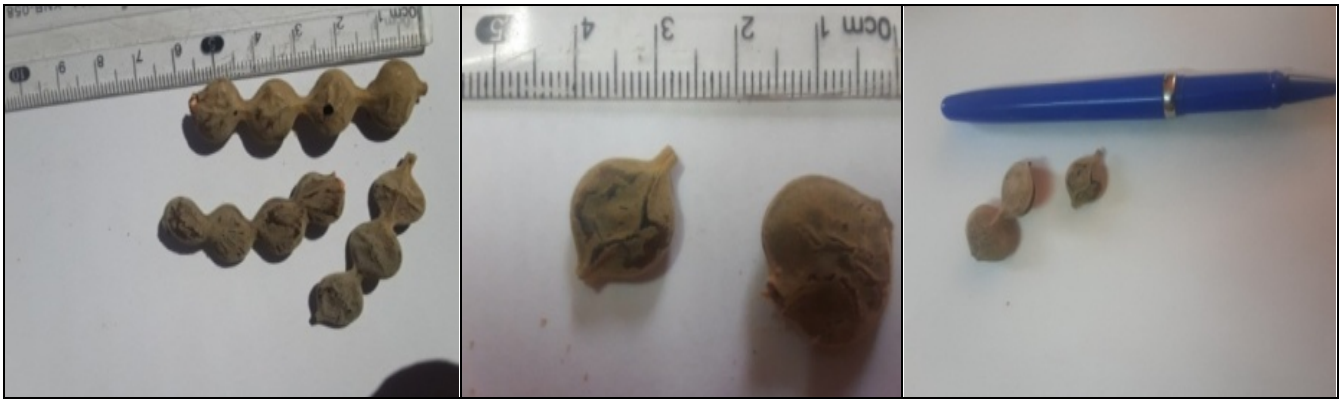

Fig 2: Photographic Album of type 1 Garad pods

Fig 3: Photographic Album of type 2 Garad pods

Fig 4: Photographic Album of a mixture of the two types of Garad pods (comparison).

Seeds were sub-circular blackish-brown, about (6-7) mm long, and 3 mm in width (Figure 5), these results are similar to what was reported by Duke (1981) [27]. Some recent studies by Mulik Abbaker *et al*. (2020) [28] showed the anatomical relation between the seed coat and seed dormancy in Acacia species.

Some authors described Garad pods as narrowly constricted between seeds, covered with a bloom or smooth, hairy, and waxy coating, and also described as inflorescence creamy, red or dark brown, and smooth pods [27].

Prathapa (2018) [24] studies had described pods as compressed, constricted at the sutures between the seeds, with a length of pod chain as 7.5 to 15 cm, and 1.3 to 1.6 cm width, mentioning that each pod chain contains 8-12 seeds. The same author reported a content of 6-16 seeds per pod chain of some Acacia pods.

The tannin content was out of our observational study objectives, but data from published literature indicated a tannin content of the husk as reported by Gasmelseed (1976) [29] of about 12%, and the grain powder contains approximately 55% tannins, while he reported no tannin in seeds. Sharma (2000) [30] study reported that the entire pod contains 12-19% tannin and after removal of seeds, the pods contain 19-27% tannin.

Fig 5: Photographic Album of Garad seeds.

The outer shell and the inner layer

On manual removal of the outer shell, or breaking a pod, there is a reddish-yellow, or brown-red powdery layer **(**flesh**)** surrounding the seed and located between the seed and the dry outer shell (the husk). This layer seems as if protecting the solid black seeds. The shell can easily be removed from the pod, and prone to be crushed under low mechanical pressure. The broken outer shell; and the Garad pod after removing the outer shell (nicked pod); were shown in figures 6; 7; and 8.

Fig 6: Broken outer shell (peel, husk).

Fig 7: Broken shell near a nicked pod

Fig 8: Garad pod after removing the outer shell (nicked pod).

Pores (holes)

We observed the presence of small holes (pores) in most pods of Garad brought from markets which store this material, while no holes were observed in somewhat younger pods from other markets (Fig 9). The presence of pores may be due to the storage conditions. Additionally, we observed more pores in the larger pods than smaller ones. This observation was logical as smaller pods were brought from the area nearby so that they were fresher when marketed and less prone to any factors that may cause the poring.

Attenborough (1995) [1] reported that Acacias contain some organic compounds said to protect them from some insects, pests, and damage by the grazing animals, but large numbers of a particular kind of small beetle fly in, pierce the pods and lay their eggs within after a few hours of the Acacia tree shedding its pods, this suggestion doesn't consider the storing condition as a factor that causes these pores on the pods. Another observation supporting Attenborough's (1995) [1] suggestion, that all pores had almost a similar regular circular shape with a similar diameter.

Fig 9: Photographic Album of pores on Garad pods

Weight of Garad pods

We expressed the approximate weight by using the weight of 100 seeds methods. One hundred garad single pods weighed 38 grams. We just aimed to give an approximate view of the density of Garad pods, which that done by

calculating the weight of 100 single pods. Notifying that the test weight is usually used for seeds, we used the technique for pods that contain seeds and other constituents.

Gasmelseed (1976) [29] had reported that seeds and husk form about 63.6% of the weight of the pod, the remainder being the grain powder. Test weight is simply used as a measure of pods bulk density and used as an indicator of general grain quality [25]. The weight of 100 seeds varies greatly for different plant species and field crops -for example, it was 29.82 for Maize, 15.73 for Soybean-white. The Great Soviet Encyclopedia (1970-1979) [31] evaluation of 1000 seed test weight on different field crops showed that for broad beans it is 1,200 g and for poppy seeds, it is 0.4 g.

Taste and sucking of Garad pods

We observed that, when sucking an intact Garad pod, the bitter taste (astringent) does not appear until the pod is being wet, or after saliva reaches the powdery layer inside the pod, which means that the bitter taste does not come from the outer shell, but rather after the saliva reaches the inner layer, and bitter tannin may be present in that layer.

Deniz Karaman (2016) [32] study indicated that the taste of Garad is almost similar to the taste of Pomegranate peel. Notifying that, Pomegranate peel contains tannin and is used in the tanning process, similarly as the use of Garad..!!

Smoke and smell

The pilot survey on a group of 200 adults from Omdurman city had shown that (80%) of the group use Garad pods both orally by sucking, and by inhaling smokes of burned pods as incense for medicinal purposes. However, many of them did not consider using the seeds (UV = 0.5).

We observed that the smaller pods (type 1) elaborate more smoke (amount approximated in the glass cub) on burning than larger pods (type 2), this observation is likely similar to the opinion of most people native citizens and expert persons on the market who believe that smaller pods (type 1) elaborate more smokes. (Figures 6,a; and 6,b are showing the appearance of burning Garad pod type 2; and burning nicked Garad pods in Mobkhar).

When the peels (shells) were separately burned, after removed from the pod, the smoke density from burning is approximately equal to the smoke density when burning the impact pod at the same conditions**.** This indicates that smoke is almost produced from the peel (shell), this was confirmed by observing a less smoke quantity

When burning the pod after removing the outer shell, or in other words, burning the inner layer with the seed (nicked pod) elaborates relatively less smoke (Fig 7-a; and Fig 7-b, are showing the smoke density when burning the impact pod; and nicked pod, respectively**)**.

The seed is a very solid black body, and it does not appear to participate in the release of smoke when burning the pod (incense).

However, assessing smokes is a complex process. Shaw & Owens (1925) [33] tried to assess smoke and haze solids from chimneys by a simple technique, they avoided the use of weight units for describing the quantity of smoke, but they established a relationship between the number of solids and intensity of light transmission [34].

Fig 10: The appearance of burning Garad pod type 2

Fig 11: The appearance of burning nicked Garad pods

Fig 12: The smoke density when burning the impact pod**.**

Fig 13: Photographic Album of the smoke density when burning the nicked pod.

Comparing some features of the two types

From our macroscopic observations, a comparison between two types of Garad pods from different environmental regions in Sudan was summarized in table 1.

Table 1: Comparing some feature of two types of Garad pods from Sudan

	Type 1 (smaller)	Type 2 (larger)
Location (Origin)	From the sub-Saharan region and the area near River Nile, such as Omdurman countryside and central Sudan.	From Western regions of Sudan such as Kordufan and subtropical regions such as southern Darfur.
Length of pod chain	Usually, the pod chains were broken into single or dual pods.	About 7 Cm. Usually, the pod chains were intact, nearly curved.
Width of pod	About 1.5 Cm	About 1.5 Cm
Segmentation (pod shape)	Deeply segmented between seeds.	Almost little segmentation between seeds.
Pod surface texture	Soft	Rough
Small pores on pods*	Less	More
Smoke density	More	Less
Weight (100 single pods)	38 g	38 g

* Maybe affected by storage conditions.

Conclusion

Through this study, formal notes were reported about two types of Garad pods (Acacia nilotica fruits) from Sudan. Some methods of using the Garad were also dealt with, which is the method of inhaling incense from burning the Garad pods. The parts and components of Garad pods were photographed and presented. Some comparisons were made between the features of the two types under study**.** Results of this study concerning differentiating the two Garad types may be used as a key for identification of Acacia species growing in Sudan. In some poor and low-level standard of life, the use of herbal alternatives is required for a healthy life. The question is: Can Garad be considered as a promising safe biological protection against microbes?. They say in the Sudanese heritage: A country that contains Garad will never contain diseases. Further pharmacological and chemical studies should be done for toxicological effects of Garad types, to suggest the suitable therapeutic doses to be taken.

Author contribution statement

Nuha Mohammed, and Sharaf Eldin Hussain, conceived of the presented idea. Nuha Mohammed developed the theory and performed the computations. Both authors together verified the methodology, Sharaf Eldin supervised the findings of this work. Both authors discussed the results and contributed to the final manuscript.

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